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Price Dispersion in OTC Markets: A New Measure of Liquidity

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Outline

Research problem

Theoretical model

Data description

Results

Microstructure of OTC markets

- Importance of over-the-counter (OTC) markets: Real estate, bond (Treasury and corporate), most new derivative markets etc.
- Microstructure of OTC markets is different from exchange-traded (ET) markets.
- Lack of a centralized trading platform: Trades are result of bilateral negotiations → Trades can take place at different prices at the same time.
- Search costs for investors and inventory costs for broker-dealers (and information asymmetry).
- Challenges of assembling market-wide data.
- Important issues of illiquidity, in crises such as the present credit crisis.

Research Questions

- In the presence of search costs for traders and inventory costs for dealers: how are prices determined in an OTC market?
- What determines price dispersion effects, i.e., deviations between the transaction prices and their relevant market-wide valuation?
- How does price dispersion capture illiquidity in such markets?
- How is the "hit rate" – the proportion of transactions within the average quoted bid-ask spread – related to illiquidity?

Literature Review

- Price quote determination in a inventory cost setting:
  - Garbade and Silber (1976, 1979), Garman (1976), Amihud and Mendelson (1980), Ho and Stoll (1980, 1983)
- Price determination in an asymmetric information setting:
  - Bagehot (1971), Glosten and Milgrom (1985), Kyle (1985)
- OTC markets:
  - Garbade and Silber (1976, 1979), Ho and Stoll (1980, 1983), Duffie et al. (2005, 2007)
- Liquidity effects in Corporate Bond Markets
  - Edwards et al. (2007), Chen et al. (2007), Mahanti et al. (2008)

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Market Microstructure Model

- There are *i* assets, *i = 1,2…I,* and a continuum of dealers of measure *J*. *j* indexes the type of the agent
- Competitive dealers face inventory costs and quote bid and ask prices depending on their desired inventory levels.
- Several investors, who have exogenously given buying and selling needs, trade with the dealers.
- Investors have to directly contact dealers to observe their price quotes ("telephone market").
- Investors face search costs every time they contact a dealer, before they can trade.

The Dealer's Decision

- Denote by $s_{i,j}$ the inventory of asset i with dealer of type j.
- Each dealer faces inventory holding costs H that are convex in the absolute quantity held, given by $H = H(s)$. Independent across assets.
- The marginal holding cost of adding a unit is approximated by $h = H'(s)$.
- Each trade incurs a marginal transaction cost function f^a *and* f^b
- Since the dealership market is competitive:

$$\text{ask: } p^a_{i,j} = m_{i,j} + f^a(h(s_{i,j}))$$
$$\text{bid: } p^b_{i,j} = m_{i,j} - f^b(h(s_{i,j}))$$

- The market's expectation of the price of asset i is defined by $m_i = E(m_{i,j})$.

The Investor's Decision

- An investor wishes to execute a buy-trade of one (infinitesimal) unit.
- The investor has contact with one dealer and is offered an ask price $p^{a,0}$.
- The investor faces search cost *c* for contacting an additional dealer; thus, she evaluates the marginal cost and benefit of doing so.
- Garbade and Silber (1976) show that the investor will buy the asset at $p^{a,0}$ if this price is lower than his reservation price p^{a*}.
- The reservation price solves:

$$c = \int_0^{p^{a*}} (p^{a*} - x) g^a(x) dx$$

where $g^a(.)$ is the density function for the ask price when contacting an arbitrary dealer.

Price Dispersion and "Hit Rate"

- Assumption for inventory holding distribution:
  - Uniformly distributed with mean zero (zero net supply)
  - Support from –S to +S, independent across assets
- Assumption for cost functions:

$$f^a = \gamma - h(s) \quad and \quad f^b = \gamma + h(s)$$

- Assumption for the holding costs:

$$H = \alpha s^2/4 \quad \rightarrow \quad h = \alpha s/2$$

- Assumption for the fixed trading cost:

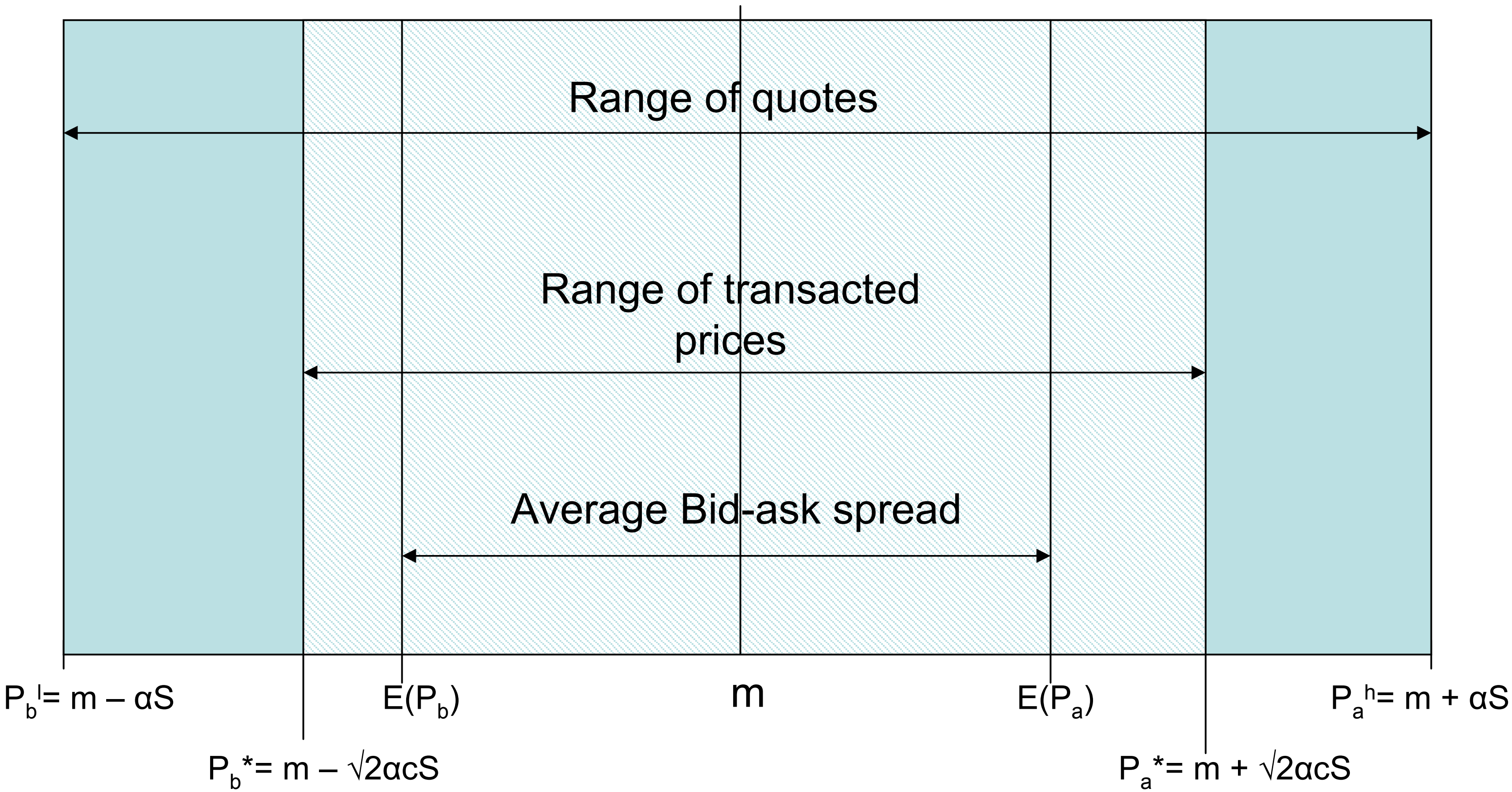
$$\gamma = \alpha S/2$$

- Solving for the reservation prices for a trader gives:

$$p^{a*} = m + (2c\alpha S)^{0.5} \text{ and } p^{b*} = m - (2c\alpha S)^{0.5}$$

- Ask and bid prices, when contacting a dealer are uniformly distributed with supports *[m; m+αS]* and *[m; m-αS]*

Graphical depiction of solution – zero net inventory



Price Dispersion and "Hit Rate"

- Based on this setup, the dispersion of transacted prices p_k from the market's valuation, *m,* have a mean zero and variance equal to:

$$E(p_k - m)^2 = \begin{cases} (2/3)\, c\alpha S \text{ if } c \le \alpha S/2 \\ (1/3)\, \alpha^2 S^2 \text{ if } c > \alpha S/2 \end{cases}$$

- Percentage of trades that fall within the median quote (hit-rate) can be derived:

$$HR = \begin{cases} 50\% \text{ if } c > \alpha S/2 \\ \dfrac{\sqrt{\alpha}\, S}{2\sqrt{2c}} \text{ if } \alpha S/8 \le c \le \alpha S/2 \\ 100\% \text{ if } c < \alpha S/8 \end{cases}$$

Liquidity Measure

- Based on the model we propose the following new liquidity measure for bond *i* on day *t*:

$$d_{i,t} = \sqrt{\frac{1}{\sum_{j=1}^{N_{i,t}} V_{i,j,t}} \cdot \sum_{j=1}^{N_{i,t}} (p_{i,j,t} - m_{i,t})^2 \cdot V_{i,j,t}}$$

where $N_{i,t}$ … number of transactions, for bond *i* on day *t*

$p_{i,j,t}$ … transaction price for $j = 1$ *to* $N_{i,t,}$ for bond *i* on day *t*

$V_{i,j,t}$ … trade volume $j = 1$ *to* $N_{i,t,}$ for bond *i,* trade *j,* on day *t*

$m_{i,t}$ … market-wide valuation, for bond *i* on day *t*

- Intuition behind the measure: Sample estimate of the price dispersion using all trades within a day.

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Data for the Present Study

- Time period: October 2004 to October 2006
- US bond market data from three sources:
  - TRACE: all transaction prices and volumes
  - Markit: average market-wide valuation each trading day
  - Bloomberg: closing bid/ask quotes at the end of each trading day
  - Bloomberg: bond characteristics

→ 1,800 bonds with 3,889,017 transactions:

- Dollar denominated
- Fixed coupon or floating rate
- Bullet or callable repayment structure
- Issue rating from Standard & Poor's, Moody's or Fitch
- Traded on at least 20 days in the selected time period

Data for the Present Study

- Selected bonds represent:
  - 7.98% of all US corporate bonds
  - 25.31% (i.e., $1.308 trillion) of the total amount outstanding
  - 37.12% of the total trading volume
- Available bond characteristics:
  - Coupon, maturity, age, amount issued, issue rating, and industry
- Available trading activity variables:
  - trade volume, number of trades, bid-ask spread and depth (i.e., number of major dealers providing information to Markit)

Data for the Present Study

- Trading frequencies:

Days per year	10/2004 to 10/2005	10/2005 to 10/2006
> 200	411	392
151 – 200	309	369
101 – 150	236	322
51 – 100	221	222
≤ 50	444	459
Total # bonds	1621	1704

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Empirical Results – Market Level Analysis

- Volume-weighted average difference between TRACE prices and respective Markit quotations is 4.88 bp with a standard deviation of 71.85 bp → no economically significant bias.

- Price dispersion measure (i.e. root mean squared difference) is 49.94 bp with a standard deviation of 63.36 bp.

- Market-wide average bid-ask spread is only 35.90 bp with a standard deviation of 23.73 bp.

- Overall, we find significant differences between TRACE prices and Markit composite that cannot be simply explained by bid-ask spreads or trade time effects.

Empirical Results – Bond Level Analysis

- At the individual bond level, we relate our liquidity measure to bond characteristics and trading activity variables to show its relation to liquidity.
- We employ cross-sectional linear regressions using time-weighted averages of all variables.
- We present results based on the whole time period, as well as based on each available quarter (2004 Q4 to 2006 Q3).
- To further validate the results, we analyze the explanatory power of our liquidity measure in predicting established estimators of liquidity → Amihud ILLIQ measure.

Empirical Results – Bond Level Analysis

- Cross-sectional regressions with the new price dispersion measure as dependent variable:

	2004 Q4	2006 Q3	Overall
Constant	231.732***	167.760***	187.648***
Maturity	2.576***	1.453***	1.840***
Amount Issued	-5.597***	-3.710***	-3.060***
Age	3.849***	1.242***	2.064***
Rating	2.090***	1.096***	1.254***
Bid-Ask	0.237***	0.544***	0.568***
Trade Volume	-7.963***	-6.023***	-8.458***
R^2	44.9%	49.3%	61.5%
Observations	1270	1513	1800

Empirical Results – Bond Level Analysis

- To validate these results, we compare the new measure to established estimators of liquidity in the literature.
- One important approach to measure liquidity is through the price impact of trading. A popular (and intuitive) measure was introduced by Amihud quantifying the effect of trading on price changes.
- Cross-sectional univariate regressions with the Amihud measure as dependent variable:

	2004 Q4	2006 Q3	Overall
Constant	-18.192***	-18.377***	-17.932***
Price Dispersion	0.021***	0.027***	0.025***
R^2	22.0%	27.3%	31.3%
Observations	1169	1426	1800

Empirical Results – Hit Rate Analysis

- Many studies use bid-ask quotations (or mid quotes) as proxies for traded prices. Our data set allows us to validate this assumption.
- The hit-rate for the TRACE price is 51.37% (i.e., in these cases, the traded price lies within the bid and ask quotation)
- Deviations are symmetric → 50.12% are lower than the bid and 49.88% are higher than the ask.
- Even the hit rate of the Markit quotation (58.59%) is quite low.
- Overall, we find that deviations of traded prices from bid-ask quotations are far more frequent than assumed by most studies.

Conclusions

- A new liquidity measure based on price dispersion effects is derived from a market microstructure model.
- The proposed measure is quantified in the context of the US corporate bond market.
- It is larger and more volatile than bid-ask spreads and shows a strong relation to bond characteristics and trading activity variables, as well as established liquidity proxies.
- A “hit-rate” analysis shows that bid-ask spreads can only be seen as a rough approximation of liquidity costs.
- The proposed measure can potentially explain and quantify the liquidity premia.
- These findings foster a better understanding of OTC markets and are relevant for many practical applications, e.g. bond pricing, risk management, and financial market regulation.